



# ***PEO/SYSCOM Conference***

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## ***Implementing Technical Performance Measurement***

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- **What the Literature Says**
- **Technical Performance Measurement**
  - *Concept/Definitions*
  - *Discussion*
  - *Pilot Program*
- **Key Elements**
  - *Technology Readiness Levels*
- **What's Next**
- **Summary**



# The Question

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- **Can you plan with some accuracy, so as to allocate your resources to reduce risk in (and while) meeting requirements, and obtain timely feedback in order to make planning and performance adjustments?**

# The Beginning<sup>1</sup>

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- **The Program Manager must be cognizant of three basic program elements (baselines): cost, schedule, and technical performance**
  - The first two are tracked through cost and schedule control systems (earned value)
  - The last is tracked through the technical performance measurement (TPM) system
    - TPM is the program manager's early warning system
- **TPMs, when correlated to cost and schedule reports, provide the complete status of the program**

# TPPs and TPMs<sup>2</sup>

- **Technical Performance Parameters (TPPs)** should indicate key areas for risk reduction and program success
- **Technical Performance Measures (TPMs)** are a **time-phased progress plan** for achievement of critical TPPs
- **TPM Methodology includes:**
  - Selecting TPPs; assigning weights; linking to CWBS; planning progress over time; getting data; **evaluating variances**; and taking corrective action as needed
  - Variances can indicate level of risk and detect new risks before their effects on cost/schedule are irrevocable
- **TPM System software available to**

## Measures<sup>3</sup>:

- **Assess** technical characteristics of the system and identify problems through tests/analyses
  - Assessments should be planned to coincide with cost reporting and completion of significant design tasks
- Can surface inadequacies in time and dollars
- Complement cost/schedule performance measurement
- Can provide basis for cost/schedule revisions
- Facilitate the **verification** of results

# Relationship of Technical Planning to Performance Measurement

- **Technical task planning<sup>3</sup> (results in technical baseline)**
  - Provides the foundation for cost and schedule planning
  - Forms the basis for allocating resources
  - Allocated resources form the performance measurement baseline
- **Performance Measurement Baseline<sup>4</sup>**
  - Provides the Budgeted Cost of Work Scheduled and is the measure against which schedule and cost variances are calculated

- **The (systems) engineering process defines the technical processes and interfaces, provides the **technical baseline**, and ensures the product meets customer cost, schedule, and performance needs<sup>5</sup>**
- **One element of the (systems) engineering process is **systems verification**<sup>5</sup>**

## Verification<sup>5</sup>

- The **incremental, iterative** determination of progress in satisfying technical requirements and program objectives
- Provides a rigorous, quantitative basis for validation and verification of specification requirements
- Is a combination of inspections, **analyses, assessments**, demonstrations, and tests which authenticates cost/performance of the system
- Includes the validation of analytical methodologies as part of verification process

# First Summary

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- **There is a linkage, a correlation between the technical and cost/schedule baselines**
- **TPMs are an indicator of technical baseline integrity**
  - A product of systems engineering and verification
  - Provides the basis for cost/schedule revisions
  - An early determinant of risk and future problems
- **EV control accounts should be modified based on TPM variances**
  - Is there a hard link between TPM performance and eventual EV control account variances?

# TPM: Concept

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- **Our efforts were based on a concept put forth by Cmdr Nick Pisano (USN Ret), now VP with C/S Solutions which produces Winsight software**
  - In 1995, he wrote a paper titled “[Technical Performance Measurement](#), Earned Value, and Risk Management: An Integrated Diagnostic Tool for Program Management”
  - He was also responsible for development of the Technical Performance Measurement System (TPMS) software

# TPM: Concept

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- “Currently reported earned value data contains invaluable planning and budget information with proven techniques for program management, however, shortcomings of the system are its **emphasis on retrospection** and **lack of integration** with technical achievement.”

**Technical Performance Measurement, Earned Value, and Risk Management: An Integrated Diagnostic Tool for Program Management, Cmdr Nick Pisano**

# TPM Discussion: Definitions

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- **Uncertainty:** indeterminate; may or may not occur; outcome could be good or bad
- **Risk:** possibility of a negative occurrence
- **Risk Management:** actions taken to reduce risk to acceptable levels
  - Risk Analysis: makes a probabilistic determination of an adverse consequence, thereby beginning the process of removing uncertainty
- **Problem:** a risk that has achieved a 100% probability

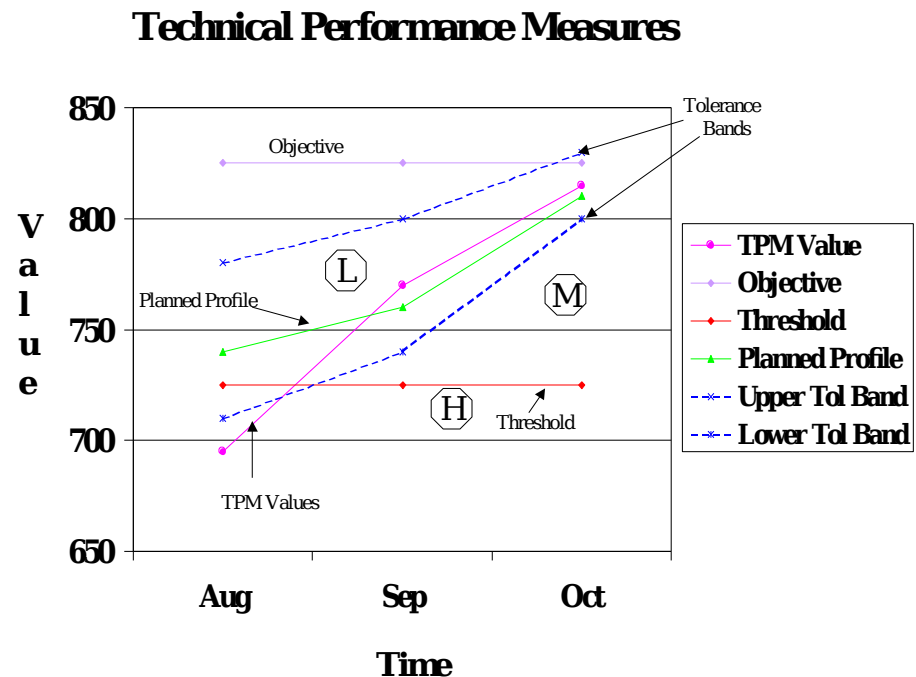
- **Earned Value:** value of completed work expressed in terms of the budget assigned to that work
- **Significant Variance:** difference between planned & actual performance requiring further analysis or action
- **Variance Thresholds:** generally stated as a % or \$ amount of BCWS or BCWP
  - Variance thresholds are set to ensure ***proper analysis of significant problems***

# TPM Discussion: Definitions

## • Technical Performance Measurement:

Comparison of technical performance, estimated or actual, and planned performance

- Method to monitor technical risk of a program
- Can provide ***early detection or prediction of problem*** manageme



# TPM Discussion: AFMC

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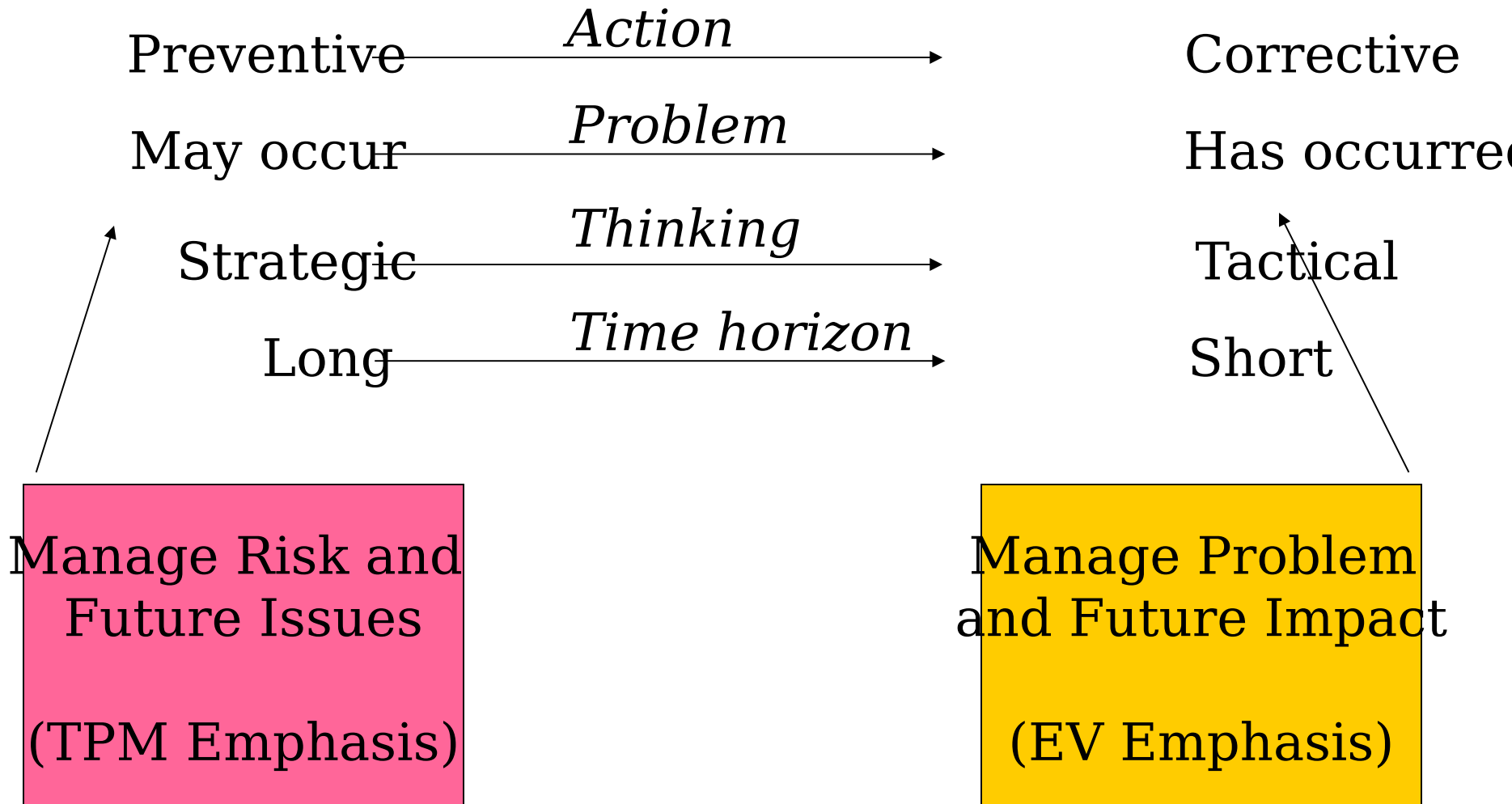
## Note

- To efficiently use TPMs, sufficient TPMs must be jointly selected by the program office and the contractor(s) to ***cover all of the key program requirements***. The technical parameters chosen ***must be capable of being analyzed and measured early in the program***.
- If an accurate assessment cannot be done early, ***the TPM will not provide timely risk management data***.
- A requirement to establish and use TPMs ... and ***the necessary work tasks to perform design analyses and tests to support TPMs must be***

## TPM Discussion:

### What's the Problem?

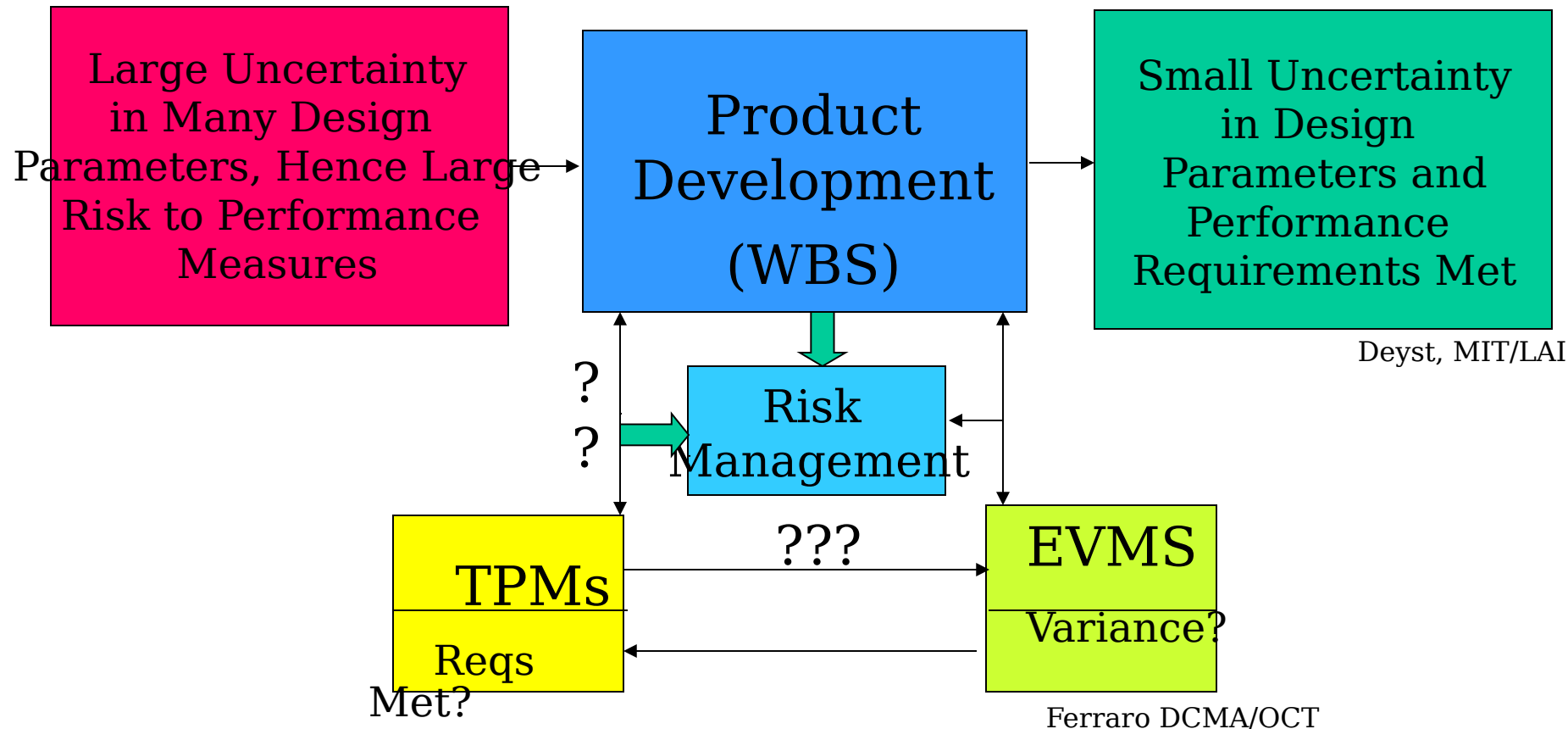
**Is it a Risk .....or a Problem**



# TPM Discussion: Integration

Initial State

Final State



*Work/Analyze like you plan*

# TPM Discussion: Planning & R

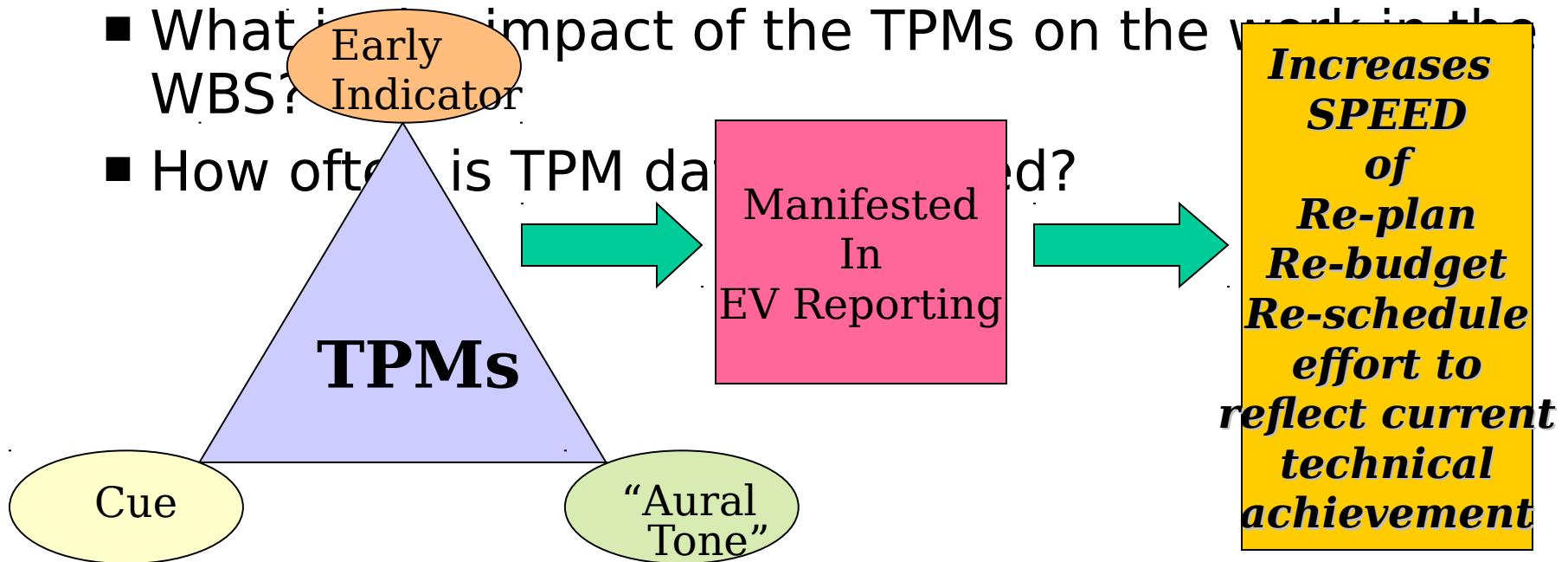
- Gaps in information and timeliness create **RISK**

- How well do you plan?

- Do you ever have, or expect, to re-plan?

- How much of WBS progress can be measured?

- What is the impact of the TPMs on the work in the WBS?
  - How often is TPM data updated?



- **Seven Contract Management Offices volunteered for the TPM pilot**
  - DCMs Long Beach and Denver in the West
  - DCMs LM Delaware Valley, LM Owego, Sikorsky, Springfield, and Raytheon Tewksbury in the East
- **Two kickoff meetings held in April 2001**
  - 17-19 April at DCM Long Beach
  - 25-26 April at DCMDE headquarters
- **Coordinated efforts with Earned Value Center**

# TPM Pilot Training Exercise

		<b>WBS to TPM Correlation</b>			<b>DATE: 06/10/01</b>			
WBS				TPMs	TPM Impact (effect on and coverage of WBS)	BCWP Affected by TPMs	TPM T.S.	New BCWP "TP M Informed"
2.1								
Airframe				Airframe Weight	0.5	125	0.97	121.25
Structure				Wt of Aux Comps	0.05	12.5	0.97	12.13
	<b>Current</b>	<b>New</b>		Weapons Weight	0.2	50	1.00	50.00
BAC	\$300M			Cooling System Wt	0.03	7.5	0.78	5.85
BCWP	250	241.70		Displays/Wiring Wt	0.02	5	0.80	4.00
BCWS	257			Navigation Sys Wt	0.05	12.5	0.99	12.38
ACWP	255			Radar Weight	0.08	20	0.93	18.60
CV%	-2.00	-5.50		TOTAL	0.93	232.5		224.20
SV%	-2.72	-5.95						
				Other (not affected by TPMs)	0.07	17.5	1.00	17.5
				NEW TOTAL	1.00	250		241.70
				Composite Technical Score			0.97	

# TPM Pilot Training Exercise

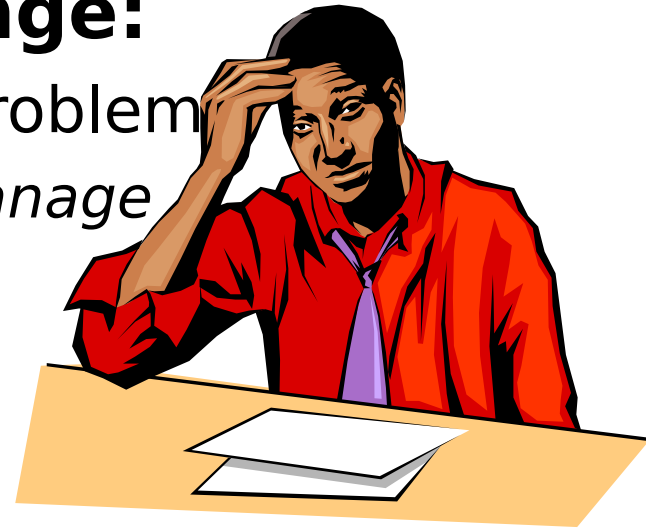
	DATE: 06/10/01				SUMMARY				
									Composite
	CV%	CV%		SV%	SV%		TPM		Technical
	Current	New		Current	New	No. of TPMs	Coverage		Score
WBS		"TPM Informed"			"TPM Informed"				
1.1 Aircraft Weight	-1.67	-4.65		1.69	-1.21	7	1.00		0.97
2.1 Airframe Structure	-2.00	-5.50		-2.72	-5.95	7	0.93		0.97
3.1 Weapons Load	-2.00	-2.62		2.56	1.95	2	0.60		0.99
4.1 Cooling Capacity	-3.45	-15.20		-3.33	-13.19	2	0.50		0.90
5.1 Display Functionality	-17.14	-18.16		-17.65	-18.35	1	0.10		0.99
6.1 Avionics Weight	-6.00	-10.36		-4.76	-8.52	2	0.95		0.96
7.1 Aircraft Endurance	-4.17	-6.13		1.69	-0.19	5	0.70		0.98
8.1 Aircraft Range	-4.71	-5.98		-2.30	-3.47	3	0.60		0.99
9.1 Aircraft Speed	-13.33	-15.06		-7.41	-8.80	3	0.60		0.99

- **Desired end state... ultimate goal?**
  - Predictive analysis of cost/schedule/performance problems
  - Integration of TPMs with work breakdown structure, earned value, and risk management
  
- **Did we get there?**
  - Needed program(s) with good traceability between WBS elements, EV control accounts, requirements, and TPMs
  - Needed to show predictive success and/or an enhancement in program and risk management

# TPM Pilot: Results

- **Pilot program was a challenge:**

- TPMs not on contract; contract problem
  - *Or, a large number of TPMs to manage*
- Requirements not defined
- Inadequate WBS structure
  - *Problem correlating TPMs to WBS*
- EV to WBS relationship not clear



- **But there were many benefits:**

- Greater understanding of contract/system requirements
- Better insight into risk assessment
- Reinforces concept of “performance-based” contracting
- Forces a systematic approach to analyzing

# Key Elements

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- **Traceability** - Requirements to WBS to TPMs to EV control accounts.
- **Impact** - How much WBS work, & therefore EV money, is covered by the TPM(s)? What is effect?
- **TPM Banding/Sensitivity** - What banding (R/Y/G) and sensitivity (EV impact) should be used for each TPM?

## **Bonus Key:**

- **Technical Readiness Level** - What's the state of the technology supporting the requirement(s) for which TPM is a metric?

# TECHNOLOGY READINESS LEVELS AND THEIR DEFINITIONS

Technology readiness levels	Descriptions
1. Basic principles observed and reported.	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.
2. Technology concept and/or application formulated.	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept.	Active research and development is initiated. This includes analytical and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment.	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment.	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.

# TECHNOLOGY READINESS LEVELS AND THEIR DEFINITIONS

## Technology readiness levels    Descriptions

6. System/subsystem model or prototype demonstration in a relevant environment.	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment.	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and "flight qualified" through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9. Actual system "flight proven" through successful mission operations.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.

# Technology Readiness Levels

- **GAO Report showed technologies introduced at TRLs of 5 or lower encountered maturation difficulties and contributed to problems in product development.**
- **Those products whose technologies reached high TRLs when they were introduced were better able to meet cost, schedule, and performance requirements.**
- **As each succeeding level of readiness is demonstrated, unknowns are replaced by knowledge and gap is reduced.**

**60 - 120%**

**0%**

# TPM to WBS Correlation with TRLs

TPM to WBS Correlation								
TPMs			TRL	TRL Risk Factor	WBS #s affected	WBS Description	TRL	Risk Factor
Aircraft Weight			4.0	0.8	1.1	Aircraft Weight	1	1.2
					2.1	Airframe Structure	2	1
					7.1	Aircraft Endurance	3	0.9
					8.1	Aircraft Range	4	0.8
					9.1	Aircraft Speed	5	0.7
							6	0.6
Airframe Weight			4.0	0.8			7	%MR
					2.1	Airframe Structure	8	%MR
					3.1	Weapons Load	9	%MR
					1.1	Aircraft Weight	<b>Contract MR</b>	0.15
					7.1	Aircraft Endurance		
					8.1	Aircraft Range		
					9.1	Aircraft Speed		
Weapons Weight			7.0	0.15	3.1	Weapons Load		
					1.1	Aircraft Weight		
					2.1	Airframe Structure		
					7.1	Aircraft Endurance		
					8.1	Aircraft Range		
					9.1	Aircraft Speed		

# EV Assessment with TRL Factor

		<b>WBS to TPM Correlation</b>				<b>DATE: 06/10/01</b>			
WBS				TPMs	TPM Impact	BCWP	TPM	TRL	New BCWP
	<b>Contract</b>				(effect on and	Affected	T.S.	Risk	"TPM Informed"
	<b>MR%</b>	15			coverage of WBS	by TPMs		Factor	with TRL factor
2.1									
Airframe				Airframe Weight	0.5	125	0.97	0.8	118.25
Structure	<b>Current</b>	<b>New</b>		Aircraft Weight	0.05	12.5	0.97	0.8	11.83
	<b>CUM</b>			Weapons Weight	0.2	50	1.00	0.15	50.00
BAC	\$300M			Cooling System Wt	0.03	7.5	0.78	0.7	4.70
BCWP	250	235.33		Displays/Wiring Wt	0.02	5	0.80	0.7	3.30
BCWS	257			Navigation Sys Wt	0.05	12.5	0.99	0.8	12.28
ACWP	255			Radar Weight	0.08	20	0.93	0.8	17.48
CV%	-2.00	-8.36		TOTAL	0.93	232.5			217.83
SV%	-2.72	-8.43							
				Other (not affected by TPMs)	0.07	17.5	1.00		17.50
				NEW TOTAL	1.00	250			235.33
				Composite Technical Score			0.94		

# Data Summary Comparison with

## TRL Factor

DATE: 06/10/01				SUMMARY			
	CV%	CV%	SV%	SV%		TPM	Composite
	Current	New	Current	New	Number of TPMs	Coverage	Technical Score
WBS		"TPM Informed" with TRL factor		"TPM Informed" with TRL factor			
1.1 Aircraft Weight	-1.67	-7.04	1.69	-3.41	7	1.00	0.95
2.1 Airframe Structure	-2.00	-8.36	-2.72	-8.43	7	0.93	0.94
3.1 Weapons Load	-2.00	-3.11	2.56	1.46	2	0.60	0.99
4.1 Cooling Capacity	-3.45	-25.15	-3.33	-20.10	2	0.50	0.83
5.1 Display Functionality	-17.14	-21.27	-17.65	-20.45	1	0.10	0.97
6.1 Avionics Weight	-6.00	-14.11	-4.76	-11.53	2	0.95	0.93
7.1 Aircraft Endurance	-4.17	-7.75	1.69	-1.69	5	0.70	0.97
8.1 Aircraft Range	-4.71	-7.02	-2.30	-4.41	3	0.60	0.98
9.1 Aircraft Speed	-13.33	-16.48	-7.41	-9.91	3	0.60	0.97
		Without TRL factor		Without TRL factor			
1.1 Aircraft Weight	-1.67	-4.65	1.69	-1.21	7	1.00	0.97
2.1 Airframe Structure	-2.00	-5.50	-2.72	-5.95	7	0.93	0.97
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# Using TPMs as the Tech

## • **Baseline Benefit to Contractors and PMOs**

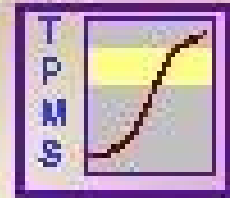
- Technical Baseline well defined vs just described
  - TPMs must be depicted by a planned profile
- Allows for computation of technical variance
  - Complements EV cost/schedule variances
- Prepares contractor to meet Level 2 and 3 of CMMI
  - Level 2...Measurement and Analysis
  - Level 3...Analyze Requirements
- Makes for good planning discipline; helps you to:

# What's Next?

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- **Working with Northrop Grumman to do a proof-of-concept on a well structured program**
- **Reaching out to Program Management Offices, other suppliers/organizations, selected CMOs**
  - ***Briefed at Integrated Program Manager's Conference***
  - ***Briefed National Defense Industrial Association (NDIA)***
  - ***Briefed Lean Aerospace Initiative Plenary (Product Development breakout session)***
  - ***Article to be published in***

## Summary of Benefits



- Produces results based on technical achievement
- Integrates technical performance with budget and schedule - providing a systems approach
- Establishes linkage between engineering and cost considerations in program management decision making
- Measures the programmatic impact of technical variance in terms of risk
- Reduces subjectivity through the establishment of a technical performance baseline

**From 1998 Briefing by Reed White**

- 1. Systems Engineering Management Guide; Jan 1990**
- 2. Top Eleven Ways to Manage Technical Risk; Office of the Assistant Secretary of the Navy (RD&A), Acquisition and Business Management; October 1998**
- 3. Systems Engineering Guide Version 1.1; 5 April 1996**
- 4. Guidelines for Successful Acquisition and Management of Software-Intensive Systems: Volume 1 Version 3.0; May 2000**
- 5. Key Supplier Processes for Aeronautical Sector Acquisition and Sustainment Programs; 20 May 1997**

# **BACKUP CHARTS**

- **Integrated Baseline Review\***

- Confirms that the Performance Measurement Baseline (PMB) ***captures the entire technical scope of work***, identifies risks, and represents the ***actual plan*** for accomplishing the remaining work and addressing both identified and ***evolving risk issues***.

- **Work Breakdown Structure (WBS)\***

- Used to organize **collection and analysis** of detailed costs for **earned value reports** and risk management analysis and tracking.
- Establishes a structure for identifying **products**, processes, and data; **allows for comparison of metrics and data to look for comprehensive trends.**
- Is a **product of the systems engineering process.**

# Some Comments

## • Metrics and Earned Value\*

- Technical Performance Measures (TPMs) are a key set of **product metrics** that track progress toward meeting customer requirements. TPMs **traceable to WBS elements** are preferred.
- **Earned Value** is reporting system that tracks the cost and schedule progress of system development **against a projected baseline.**
  - *Projected performance is based on cost and schedule estimates of the **work required by each WBS element.***
- When **combined with product metrics, earned value** is a powerful tool for: **detecting** & understanding development **problems;** **identifying** emerging program & technical **risk.**

# Questions to Ask

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- **Are system requirements established?**
  - *Are TPMs established for system requirements?*
- **Have derived requirements been established and are they traceable to the system requirements.**
  - *How is progress determined (TPMs)?*
- **When initial EV (or IBR) baseline was established were the assumptions described and documented?**
  - *How is EV baseline updated? Technical baseline defined?*
- **Can top level and derived requirements be related to the WBS and vice versa?**
  - *Can TPMs be related to the WBS and vice versa?*
- **Can the WBS be related to the EV control**

# Bottom Line

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- Is this absolutely necessary to ensure program success? **No**
- Is all this work worth the time and effort? **Don't know**
- Will I know more about my program's progress and have a more detailed and coherent plan? **Probably**
- Can this help with functional integration and communication? **I think so**
- Is anyone else doing this? **No. But organizations are constantly looking for an edge, and researching similar approaches, for early indications of risk.**